Northern Illinois University

Magnetically Driven Piston Engine

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Department of Mechanical Engineering

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Table of Contents

Problem Statement

In recent years combustion engines have come under fire for their harmful emissions. Their electrical counterparts however, generally put out less torque than combustion engines. This is mainly because combustion generates more force than electromagnetics does. However, there is another difference between combustion engines and electric motors. Electric motors generate rotary motion while combustion engines convert reciprocating motion into rotary motion. The purpose of this project is to see if magnetics can be used as the driving force in a piston engine, and if the conversion of reciprocating motion into rotary motion gives an advantage or disadvantage to motor performance.

Specifications

Building a multi-pistion engine is too complex for the scope of this project and the given time frame so a single piston was decided on. A prototype was built to be tested against an electric motor from a radio controlled toy car. Both motors were to be run off of a six cell, 7.2 volt D.C. battery common to many radio controlled cars. The prototype was designed to be self sufficient, meaning any controls should also run off the battery. The motors were to be tested versus each other on various aspects of their performance, such as up hill performance, towing performance, longevity (battery life,) and potential speed.

Concept Selection

Magnetic coils are a widely used component in many areas of industry. Some uses include brakes, clutches, actuators, and cranes. A basic magnetic coil consists of a metal core wrapped by a length of wire. The force of magnetism generated is proportional to the electric current and the number of turns in the wire coil. When current is applied to the coil, the core becomes polarized. The direction of the current and the right hand rule can be used to determine which end of the core is a north pole and which end is a south pole. By reversing the current the polarity in the coil is reversed.

By introducing a permanent magnet to the coil, the coil will either repel the magnet if like poles are brought together or attract if opposite poles are brought together. The prototype was created by attaching the permanent magnet to the piston and mounting the coil above the piston. Like poles are used to repel the piston on the downstroke and opposite poles are used to attract the piston on the upstroke. This is the basis for the reciprocating motion created by the magnetics.

The piston is connected to the crankshaft via a connecting rod. As the piston is repelled, it forces the connecting rod to turn the crankshaft. This is where the reciprocating motion is transferred into rotary motion. A flywheel was mounted to the shaft to maintain rotation while the current is reversed. See figure 1 for motor assembly.

To control the flow of current through the coil, a simple flip flop device was to be used with an optical sensor. A semicircular paper disc was attached to the flywheel and the optical sensor was positioned behind the paper disc. The sensor was oriented so that the paper disc blocked light from the optical sensor during the engine's upstroke and allowed light to reach the sensor during the downstroke. The sensor would send a logic high to the flip flop when the sensor received light and a logic low when it received no light. This alternating high and low signal told the flip flop when to reverse the current to the coil.

A problem arose with the current required to generate the magnetic field. The electrical components could not handle the high current required to force the piston down. The current needed in the coil was in the range of three to four amps. The maximum current the flip flop circuit could handle, however, was 120 milliamps. The flip flop also required a fourteen volt D.C. power source for optimum performance. As a solution to this, an op-amp was installed between the battery and the flip flop to reduce the current supplied to the flip flop. Another op-amp was inserted between the flip flop and the coil to boost the current back up to the required amount for the coil. The problem with the op-amps was that a 32 volt power source is required to power the op-amps. This becomes very impractical because three separate power sources are needed to make this design work.

An alternative method of controlling the current to the coil was tried. A copper disc was attached to the flywheel to act as an electrical connection. This design required two batteries to be used. The positive lead of one battery and the negative lead of the other were both tied to one lead from the coil to act as a ground. The remaining positive lead was placed so that it was touching the front of the copper disc. The remaining negative lead was also placed so that it was touching the front of the copper disc 180 degrees apart from the positive lead. The remaining lead from the coil was placed so that it was touching the back of the copper disc. A layer of electrical tape was placed on the front of the copper disc so that only half of the metal face was showing. This allowed only one of the battery leads to touch the copper face of the disc at any time. See figure 2 for control assembly.

The problem with this design was that the leads created too much friction, not allowing the coil to move the piston. As a solution, a string was attached to and wrapped around the flywheel to act as a pull string. This created enough inertia to start the motor going. However, after the string was pulled, the motor quit after half of a complete turn because the friction was still too great. Unfortunately, what was left was a non working prototype. The closest the prototype came to running was by manually connecting one coil lead to each battery lead and switching the leads to reverse the current.

Component Design

A piston, rod and crankshaft assembly can be very difficult to machine from scratch. Therefore a single piston radio controlled car engine was purchased as the base of the prototype. The first step in the prototype design was to remove the carburetor and airfilter. These are unnecessary parts because no combustion will take place in the prototype. The air filter was mounted to the engine block directly above the piston by six small bolts. This is where the coil was mounted to the engine.

The coil itself consisted of a piece of barstock steel approximately six inches long, with a plastic plumbing flange glued to each end. Thirty feet of wire was wrapped around the steel core with the two leads exposed. Six holes were drilled into the bottom flange and the six air filter mounting bolts were used to attach the coil to the engine block. Small, flat washers were used to space the coil so that the core and piston would not touch. The copper disc was cut from a thin sheet bought from Ace Hardware.

All electrical components were purchased at Radio Shack. The flywheel was purchased over the phone from Tower Hobbies and the engine was purchased at Pat's Hobbies in Oak Lawn.

Testing and Evaluation

Due to the failure of the prototype, no testing could be done. The following tests, however, would be performed on a working prototype:

Towing test - Both motors would be timed on how long they took to pull a two pound weight on a wheeled cart ten feet. The same test would also be performed using a five pound weight. Inclined ramp test - Each motor would be timed on how long it took to make it up a six fool long, ten degree incline. For the towing test and the inclined ramp test, the motors would be mounted on a car made from an Erector set. Max potential speed test - Each motor would be fixed and allowed to spin freely while the angular velocity was measured with a strobe light. Battery life test - Each motor would be allowed to spin freely and timed until the battery ran out. The time for the rotary electric motor would have to be doubled since the magnet piston engine's last design required two batteries. Both the battery life test and the max potential speed test could be run at the same time.

Recommendations

A couple of options are still possible to make the prototype work. The current could still be controlled using electrical components. However, better components would be needed, which could become more costly. Also, an electrical engineer would be very helpful in the set up of these components.

Another option is to use two or more pistons to avoid the "dead spots" at the bottom of the stroke. This, however, would require twice as many electrical components. Controlling the current into two or more coils is much too difficult for the scope and time frame of this project.

Conclusion

This was a good project in theory. In reality, however, things were much different. For controlling the current using electrical components, three separate voltage sources were needed. This is very impractical for a single engine. In using the copper disc to switch the current, the friction forces between the copper disc and the leads were too great. The use of a pull string as a starter got the motor moving, but friction was still too high and the motor could not sustain itself. It would appear that the idea that seemed good in theory was not very practical after all.

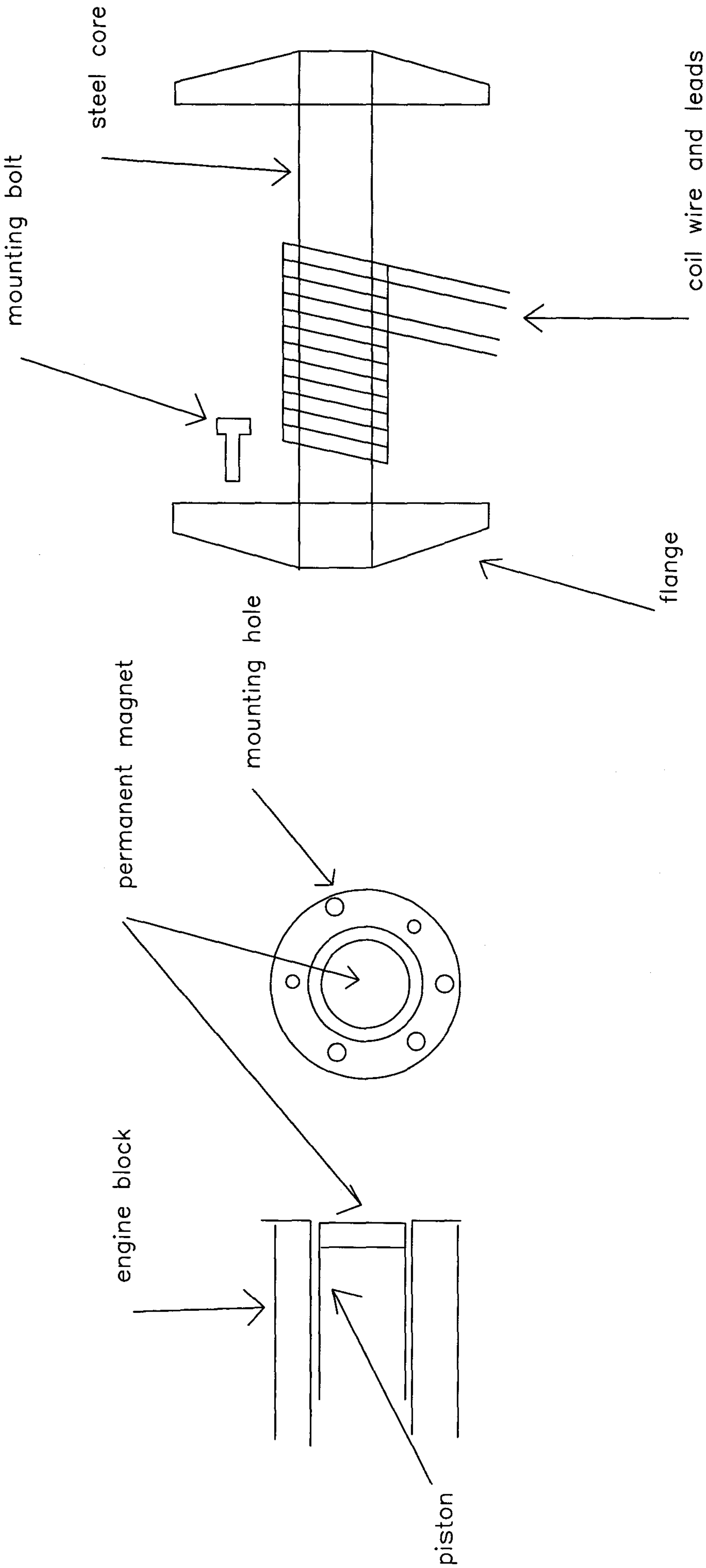

figure 1 – motor assembly

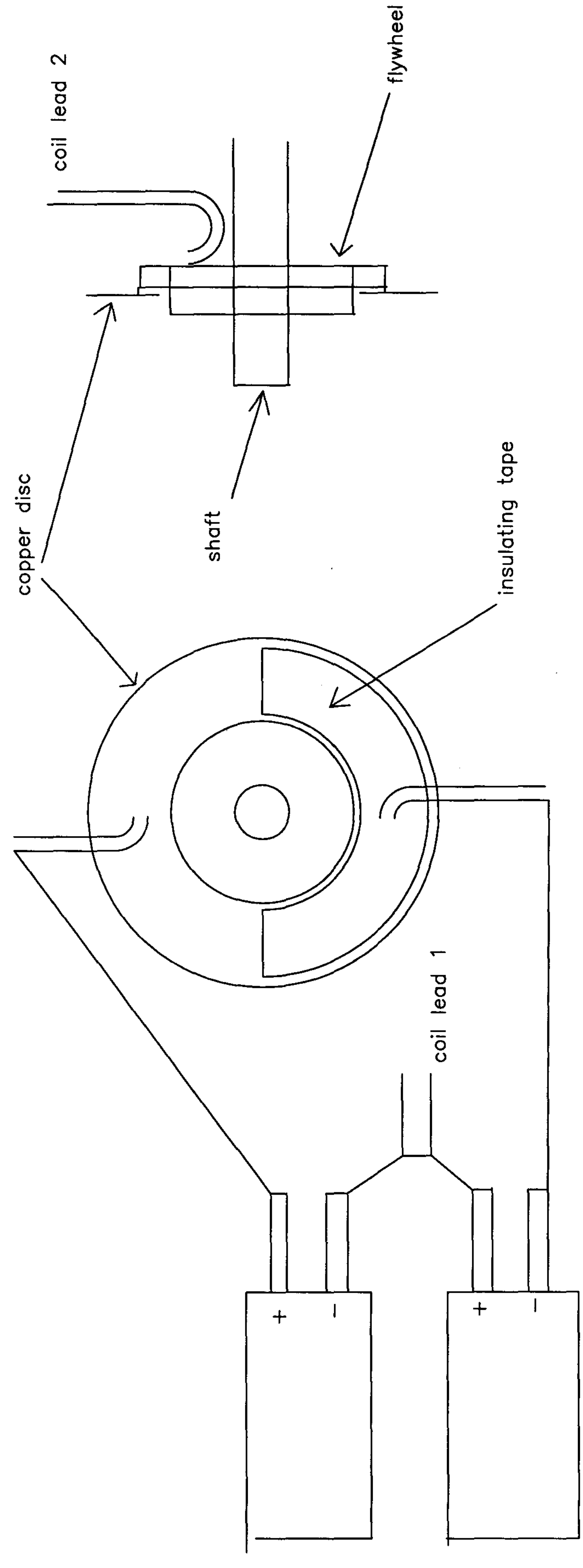

figure 2 — control assembly